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# Assessing the Impact of Open and Closed Knowledge Sourcing Approach on Innovation in Small and Medium Enterprises

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## Abstract

There is very limited research on open innovation in small and medium enterprises (SMEs). By drawing on complementarity theory and knowledge based theory, this study develops three hypotheses in order to identify the impact of knowledge sourcing approaches for innovation on SMEs' innovation performance. Surveys collected from 196 SMEs in Korea were analyzed to test the hypotheses by using supermodularity function. The results indicate no significant impact of external knowledge-oriented approach while positive impact of internal knowledge-oriented (i.e., closed approach) on innovation performance. Interestingly, this study finds that open innovation has significant negative impact on SMEs' innovation performance (i.e., both internal knowledge- and external knowledge-oriented approaches have a substitutive relationship). This study sheds new light on open innovation and knowledge management research by identifying the relationships between knowledge sourcing approaches for innovation and innovation performance in SMEs.

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*Keywords:* Open innovation; Knowledge Sourcing Approach; Substitutability, Complementarity; SMEs

## 1. Introduction

Over the past decades, open innovation defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand markets for external use of innovation, respectively” [1] has attracted a lot of attention from both academics and practitioners. The basic assumption of open innovation is that using external knowledge in conjunction with internal knowledge can increase firm performance in a rapidly changing environment. For example, Rass et al. [2] proposed that open innovation instruments positively affect firm performance through firm's social relations and networks.

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However, little research has demonstrated whether open innovation show better performance than closed innovation, despite the theoretical entrenchment of the idea that firms can use internal and external knowledge sources together. Some studies insisted that closed innovation which focuses on internal investment on R&D can increase firm performance by enabling firms to have an in-depth understanding of the strengths and weakness of its knowledge and capabilities [3-4]. Others pointed out that open innovation which focuses on combining internal and external knowledge sources can enhance firm performance by allowing firms have broader set of knowledge [5]. In order to fill these inconsistent results, many efforts have been made to investigate the conditions under which innovation approaches can be expected [6].

However, these studies have been largely performed for managers in large firms. There is very limited research on open innovation in small and medium enterprises (SMEs), although open innovation of SMEs is very important for their contribution to innovation in almost all economies. In addition, there is major differences between large and SMEs [7] and the need to adopt different innovation approaches [8]. Large variations exist between large firms and SMEs in terms of the resource that constrains a firm's ability to access, acquire, and use knowledge. Thus, viewing SMEs' innovation approaches as scaled-down versions of the innovation approaches found in larger firms is incorrect [9].

In order to explore the research gaps, this study examines how SMEs' innovation performance varies depending on knowledge sourcing approaches, defined as the extent to which an individual or organization intentionally accesses, acquires, and reuses knowledge from others such as expertise, experience, insights, and opinions [10]. For this purpose, this study first proposes three different approaches of innovation: internal knowledge-oriented, external knowledge-oriented, and open (i.e., combining internal knowledge- and external knowledge-oriented). This study then theoretically explores the positive or negative synergistic patterns in the strategic usage of knowledge sources and their impact on firm's innovation performance, by drawing on the complementarity theory from the economics literature [11].

## **2. Theoretical Background and Hypothesis Development**

### *2.1. Knowledge based theory*

Knowledge based theory (KBT) of the firm considers knowledge as the most strategically significant resource of the firm [12]. Its proponents argue that as knowledge-based resources are usually difficult to imitate and socially complex, these diverse knowledge bases and capabilities within the firms are the major determinants of sustained competitive advantage and superior firm performance [13]. Firms that are able to develop, manage and transfer this knowledge are more likely to gain sustained competitive advantage in the long run [12]. This knowledge is embedded and carried through multiple entities including organizational culture and identity, policies, routines, documents, systems, and employees [13].

A critical contribution of the KBT is the identification of two different knowledge sources for innovation: internal- and external-oriented [14]. The theory considers internal- and external-oriented sourcing as a distinct choice, thus the forces that motivate a firm toward internal-oriented knowledge sourcing may not be the same as those motivating it away from external-oriented knowledge sourcing [15]. Indeed, a substantial number of studies have discussed the relationships between knowledge sourcing and innovation performance based on internal- and external-oriented sourcing aspects. Therefore, the choice between internal-, external-oriented, or simultaneous sourcing (i.e., open innovation) becomes one of the firm's primary decisions [4].

### *2.2. Complementarity and substitutability theory*

Complementarity was formalized by the notion of supermodularity which was given by Topkis [16] and later expanded by Milgrom and Roberts [11]. The property of supermodularity in its ordinal form is narrowly

associated to the single crossing property which says that increase in the value of the objective function due to an increase in the one of the variables is preserved even after the rise of any other variable [17]. In its differential form the single crossing property articulates that the marginal gain with respect to one variable is non-decreasing in other variables. This notion is popularly known as complementarity. Milgrom and Roberts [11] formally defined the relationship between supermodularity and complementarity as - given a real-valued function  $f$  on a lattice  $X$ ,  $f$  is supermodular and its arguments are (Edgeworth) complements, if and only if, for any  $x$  and  $y$  in  $X$ ,  $f(x) - f(x \wedge y) \leq f(x \vee y) - f(y)$ . Substitutability is a concept exactly opposite of complementarity.

2.3. Developing hypothesis

This study proposes three hypotheses on the relationship between innovation approaches and innovation performance based on KBT and complementarity theory. Figure 1 summarizes the hypotheses.

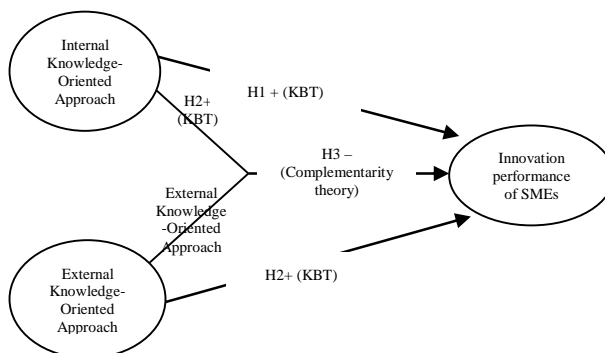


Fig. 1. Research Model

According to KBT, knowledge is an organization’s most essential and only resource that cannot be easily emulated by rivals [12], which makes it an indispensable source of uniqueness or competitive advantage [13]. As SMEs cannot compete directly with larger firms on economies of scale, they pursue niche strategies by serving narrow and smaller market segments that are often not reached or not fulfilled by larger players [18]. This is achieved by focusing on market segments that require customized products and high levels of customer service that might be difficult for larger (generalist) firms to offer [18]. Hence, these firms develop specific heterogeneous knowledge resources and capabilities that are difficult to imitate. This consequently leads to a sustained competitive advantage and superior innovation performance. We therefore propose:

**Hypothesis 1:** Internal knowledge sourcing is positively associated with SMEs’ innovation performance.

According to KBT, external knowledge enables firms get fresh ideas to complement their knowledge base, leading to higher performance [19]. SMEs are typically those firms who have restricted financial and human resources for innovation activities [20]. These firms do not have the assets to always develop knowledge internally. Additionally developing knowledge internally can sometimes be more time consuming which might mean less competitive advantage to the firm who developed the knowledge internally [21]. External knowledge is generally readily available in the marketplace to a lot of the competitors and hence this type of knowledge is relatively cheap to obtain [15]. This kind of knowledge helps firms increase their knowledge base and provides more flexibility [22]. Knowledge obtained from outside helps firms understand what its other competitors are doing and how they are doing it to remain competent in the market. Thus, this type of knowledge helps SMEs in bridging the gap between themselves and their other competitors who enjoy some competitive advantages. Additionally, by acquiring knowledge from outside SMEs tend to bridge this knowledge gap at a relatively less

cost and a smaller amount of time. External knowledge-oriented approach provides firms with economies of scale in acquiring knowledge, which in turn leads to an increase in innovation performance of the firms. This leads us to the following hypothesis.

**Hypothesis 2(H2):** External knowledge sourcing is positively associated with SMEs' innovation performance.

Many studies in the past have highlighted that adopting both internal knowledge- and external knowledge-oriented approaches are complementary in large firms and thus aid in increasing innovation performance even more when carried out together as opposed to pursuing them exclusively (e.g. [23]). However, this might not necessarily be true for SMEs. They are believed to have fewer opportunities to access external knowledge because of the small number of their interfaces to the external environment and fewer opportunities to apply this knowledge internally due to their smaller portfolio of ongoing activities [24]. SMEs are bound by their resources, capital constraints, and lack of management expertise, as well as their absorptive capacity [18, 25]. Resource and capacity are therefore inevitably important factors to be considered when implementing KSSs in the SMEs. Given the lack of resources and capacities, it is very difficult for them to integrate the two sourcing approaches seamlessly because internal (or external) knowledge sourcing often is as difficult as external (or internal) knowledge sourcing. Although the integration of different specialized knowledge sources is critical, high levels of knowledge sourcing in many areas are quite expensive, thus often unrealistic for SMEs [4]. Therefore, SMEs that attempt to adopt open innovation approach (i.e., combine internal knowledge- with external knowledge-oriented approaches) tend to be at a disadvantage, thus resulting in lower firm performance. We therefore propose:

**Hypothesis 3:** Open innovation approach (i.e., pursuing both internal and external knowledge sourcing simultaneously) is negatively or less positively associated with SMEs' innovation performance.

### 3. Research Methodology

#### 3.1. Sampling and data collection

As a sampling frame, 926 SMEs were identified from the Annual Corporation Report in Korea. Survey questionnaires were mailed to each firm's owner or senior manager who was most erudite about the company's innovation approach and performance. Out of the 926 mailed surveys 213 respondents completed the questionnaire. After eliminating the surveys with missing values, a final count of 196 firms was reached, providing an approximate response rate of 23 percent. Majority (42.05%) of the firms had total number of employees in the range of 50 to 99. Table 1 summarizes the firms' characteristics in the sample.

Table 1. Sample characteristics

(a) Industry			
Industry Type	Number of Firms	Percent (%)	Cumulative Percent (%)
Manufacturing	60	30.6	30.6
Finance	6	3.1	33.7
Service	130	66.3	100
Total	196	100	

(b) Size			(c) Age		
Firm Size	Frequency	Percent (%)	Firm Age	Frequency	Percent (%)
Less than 50	35	23.86	Less than 10	134	68.4
51 to below 100	116	42.05	10 to below 30	26	13.3
100 to below 300	36	27.84	30 to below 50	15	7.7
300 to below 500	9	6.25	More than 50	21	10.7
Total	196	100.00	Total	196	100.00

### 3.2. Reliability and validity for measures

Research constructs were operationalized on the basis of related studies and refined through a pilot test. The operational definitions of instruments and their related literature are listed and described in Table 2. Knowledge sourcing approaches pursued in a firm were measured based on previous studies [22, 26]. Innovation performance was assessed using constructs developed by previous studies [27-28].

Table 2. Operational definitions and related literature

Variables	Operational Definition	Key Studies
External-oriented	The degree to which firm seeks and use knowledge from outside of the firm (e.g., customers, suppliers, collaborations and alliance with external institutions or organizations, and external consultants) for innovation.	[19], [22]
Internal-oriented	The degree to which company depends on internal knowledge from colleagues, internal documents, existing products/service, and internal forum/(electronic) communities in developing new knowledge (e.g., products or services).	[19], [22]
Innovation performance	Degree of more flexible product/service provision, faster new product/service provision, higher-quality product/service provision, larger market share in comparison with major competitors	[27-28]
Age	The number of years a firm has existed	[22]
Industry type	0 if a firm belongs to service industry 1 if a firm belongs to manufacturing industry 2 if a firm belongs to finance industry	[22, 29]

It is also important to control factors that may influence the relationship between knowledge sourcing approach for innovation and innovation performance. First, firm age was controlled because firms that have been longer in the market typically have more access to external sources and greater internal sourcing [7]. Second, the study also controlled for industry type, as different industry environments can have impacts on firm performance [29] and affect firms' extent of use of internal versus external knowledge sources [22].

Content validity of the instrument was established through the adoption of an instrument that has already been used and validated by other researchers and through a discussion with several professionals in the innovation and knowledge management area. All variables were measured by multi-item constructs using a seven-point Likert scale. Cronbach's alpha was used for assessing the reliability of the instruments. A higher cutoff value of 0.7 was used [30]. For convergent validity, items having item-to-total correlation scores lower than 0.5 were dropped from further analysis. Factor analysis was used to check discriminant validity [31]. Items with factor loading values lower than 0.5 were deleted. Table 3 presents the results of the reliability and validity tests.

Table 3. Statistics for reliability and validity tests

Measure	Acronym	Items	Mean	S.D.	Reliability (Cronbach alpha)	Convergent Validity (Correlation of item with total score-item)	Discriminant Validity (Factor loading on single factors)
Knowledge sourcing approach	KSS	2					
Internal knowledge-oriented	IKO	4	0.371	1.463	0.929	0.799; 0.818 0.843; 0.881	0.944; 0.935 0.934; 0.916
External knowledge-oriented	EKO	4	0.342	1.596	0.950	0.899; 0.883 0.881; 0.852	0.886; 0.898 0.914; 0.936
Performance							
Innovation performance	IP	4	3.867	1.023	0.916	0.809; 0.867 0.848; 0.710	0.895; 0.930 0.919; 0.826
Age	AGE	1	16.79	15.17	NA	NA	NA
Industry types	INT	1	0.370	0.543	NA	NA	NA

### 3.3. Testing Approach: Complementarity and Substitutability

Testing for complementarity can be achieved by two different econometric approaches. The first called the correlation approach, tests conditional correlations based on the residuals of reduced form regressions of the organizational practices on observable exogenous variables [17]. The second one, the so-called productivity approach, regresses a measure of productivity on a set of regressors, including the interaction effect between different practices, and the coefficients of the interactions can be viewed as estimates of complementarity parameters [32]. This approach tests complementarity by investigating whether the production function is supermodular. Unlike the first approach, this can provide a statistical resolution for complementarity and thus it has been widely used in recent empirical work [17].

This study directly estimates the contribution of a combination of two knowledge sourcing approaches for innovation to the relevant outcome measure by using supermodularity and submodularity based on the productivity approach [33]. To formalize the hypotheses, we specify a general production function for the firm: the firm maximizes a performance measure,  $f(x)$ , with respect to the vector of four sourcing strategies,  $x =$  (internal knowledge-oriented, external knowledge-oriented). Since knowledge sourcing approaches for innovation are continuous variables, we can use interaction terms in the regression framework and test for the sign of the interaction parameters [18]. When the practices are measured by continuous values, the following definition of complementarity holds:

$$f(x_1, x_2) = \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_{12} x_1 x_2 \quad (1)$$

$f()$  is innovation performance for firm  $i$ , measured as subjective self-reported items, a widely used measure of innovation performance [27-28]. Thus,  $\alpha_{12} > 0$  (i.e., the coefficient of partial derivatives  $\partial^2 f / \partial x_1 \partial x_2$  is positive), implies that there is complementarity for internal knowledge- and external knowledge-oriented approaches while  $\alpha_{12} < 0$  means substitutability for two approaches.

## 4. Analysis and Discussion

### 4.1. Knowledge sourcing approaches and innovation performance

The data was analyzed in three steps using hierarchical regression. Table 4 summarized the analysis results. In the first step, only control variables (i.e., industry and age) were analyzed in the regression model. The results showed that age and industry type did not affect firm's innovation performance.

Table 4. Analysis Results

Variables	Step 1	Step 2	Step 3
Constant	3.846 <sup>‡</sup>	2.584 <sup>‡</sup>	1.723 <sup>‡</sup>
Step 1			
Age	0.004	0.001	0.001
Industry type	-0.122	0.000	-0.034
Step 2			
IKO (Internal knowledge-oriented)		0.293 <sup>‡</sup>	0.291 <sup>‡</sup>
EKO (External knowledge-oriented)		0.051	0.050
Step 3			
Open Innovation (IKO* EKO)			-0.127 <sup>†</sup>
F-Value =	0.879	18.858 <sup>‡</sup>	16.444 <sup>‡</sup>
Adjusted R <sup>2</sup> =	0.000	0.269	0.285
Change in R <sup>2</sup> =		0.269	0.016
Partial F (Change in R <sup>2</sup> ) =		36.512 <sup>‡</sup>	5.144 <sup>†</sup>

\*:  $p < 0.1$ , †:  $p < 0.05$ , ‡:  $p < 0.01$

In the second step, both the control variables and internal knowledge- and external knowledge oriented-approaches were included in the regression model in order to analyze main effect of them on innovation performance. Among them, internal knowledge-oriented approach was found to be significantly affecting firm performance ( $\beta=0.293$ ,  $p < 0.01$ ). Thus, the results provided strong support for hypothesis 1 which stated that internal knowledge-oriented positively affects SMEs' innovation performance. However, contrary to our expectation, external knowledge-oriented approach was not found to be significantly affecting innovation performance ( $\beta=0.051$ ,  $p > 0.1$ ). Therefore, hypothesis 2 was rejected. In the last step, the interaction term was added to the existing model. As partial coefficient distortion occurs in entering main effects and interaction terms together, this study used residual centering to reduce multicollinearity between them [34]. Residual centering can be done with a two-stage. First, interaction term is regressed onto its respective first-order effects (i.e., internal knowledge- and external knowledge-oriented approach). Second, the residuals of the regression are used to the interaction terms instead of original interaction terms. Analysis results using residual centering showed that interaction term between internal knowledge- and external knowledge-oriented approach was negative and significant ( $\beta=-0.073$ ,  $p < 0.05$ ), which support hypothesis 3. This implies that open innovation approach might not be beneficial for SMEs. Table 5 showed positive effect of internal knowledge-oriented approach on innovation approach in step 3 ( $\beta=0.291$ ,  $p < 0.01$ ). However, the main effects cannot be interpreted in the presence of the interaction terms in step 3 because main effect in step 3 represent conditionalized main effects [35].

#### 4.2. Discussion

The testing results support hypothesis 1. That is, adopting an internal knowledge-oriented approach for innovation yields a higher innovation performance. Some studies insist that internal knowledge-oriented approach can cause a firm to rely on single or a few knowledge sources to develop new knowledge, exhibiting a dysfunctional down side that inhibits innovative progress [36]. However, our results showed the positive impact of using internal knowledge-oriented approach on innovation performance. Focusing on internal knowledge allows firms to have an in-depth understanding of the strengths and weaknesses of their unique knowledge or skills so that they have more opportunities to success in innovation activities [4]. Internal knowledge can also be easily accessed and cheaply used by organizational members, while competitors have difficulty in accessing and using the firm's internal knowledge due to legal and technical barriers [14]. Therefore, firms that innovate their products/services systematically by using internal knowledge can outperform those that do not [37].

Contrary to our expectation, external knowledge-oriented approach for innovation in SMEs does not show any significant positive impact on innovation performance. The result could be explained using the institutional view, which focuses on gaining support and legitimacy by conforming to social pressures [38]. According to institutional theory, when a firm attempts to learn from external knowledge sources, they often encounter resentment and conflicts due to lack of legitimacy of the external knowledge. The external knowledge is likely to alter firm's habits and routines including patterns of resource allocations, incentive systems, and organizational structure [38]. Firms are likely to adhere to creating new knowledge based on their own previous knowledge base and their past success history prevents them from adopting external knowledge [7].

Our results support hypothesis 3. Some studies insist that SMEs are better equipped to integrate internal knowledge- and external knowledge-oriented approaches for innovation because they are more amenable to external new knowledge [7], [39], resulting in avoidance of not-invented-here (NIH) syndrome [40] or core rigidities [36]. However, our results show a substitutable relationship between internal knowledge- and external knowledge-oriented approaches in SMEs as we expected. They have less diverse knowledge assets and fewer opportunities to access and acquire knowledge across the boundaries of their firms and apply them internally. In addition, the lack of organizational and managerial resources prevents SMEs from combining existing

internal knowledge with externally acquired or internally created knowledge for improving innovation performance because this combination requires the possession of significant resources [24]. Therefore, in SMEs, open innovation does not increase innovation performance.

#### 4.3. Implications

The results have several implications for researchers and practitioners. This study has attempted to focus on knowledge sourcing approaches for innovation adopted in SMEs which have often been neglected by the past studies [41]. Although the extant literature on open innovation in large firms is vast [42], the literature is deficient in studies identifying open innovation in SMEs. Thus, the findings of this study have important implications as contrary to the conventional wisdom that states adoption of open innovation (i.e., adopting both internal knowledge- and external knowledge-oriented approaches) increases firm's innovation performance; this study identifies a negative impact of adoption of open innovation on SMEs. The results of this study suggest that pursuing both internal knowledge- and external knowledge-oriented approaches in SMEs simultaneously conforms to a substitutable effect on firm's innovation performance rather than a complementary effect. These findings are significant for SMEs in innovation and knowledge management literature as this study draws a clear demarcation among the innovation performance of firms of different sizes adopting similar innovation approaches. Hence, this study calls for a need for organizations of different sizes to have different innovation approaches.

Second, this study extends the existing knowledge by examining the complementarity of two types of knowledge sourcing approaches for innovation. Most prior studies have tended to investigate the independent effects of these approaches on innovation performance without considering their combined impacts. While a few studies such as Zahra and Nielsen [22] considered different knowledge sourcing approaches for innovation together, they only investigated the independent effects of these approaches on innovation performance such as technology commercialization. This study analyzes two different knowledge sourcing approaches for innovation simultaneously and provides empirical evidence on substitutable relationships between them. Furthermore, this study tests complementarity and substitutability based on the productivity approach that has been considered as a definitive test method for complementarity and substitutability.

Last implication is directed to managers in SMEs. Our finding proves that adopting knowledge sourcing approach for innovation, from both internal and external environment may not be a good initiative for SMEs. Although, further studies should be carried out in this area, it is apparent from this study that managers of SMEs should focus on internal knowledge-oriented approach for innovation. Additionally, pursuing an internal knowledge-oriented approach (i.e., closed approach) would mean that firms would require a relatively less budget as compared to the finances needed for pursuing open innovation both internal and external strategies simultaneously. Firms concentrating on a single approach shall also help them remain focused in their innovation activities. This should help the firms in their ability to conform their innovation approach with their organization goals in an easier and much more proficient way, thus increasing the firm's capability to maximize the benefit from the newly developed expertise as well as pre-existing capabilities.

#### 5. Conclusion

Firms should carefully choose their knowledge sourcing approaches for innovation to establish and maintain sustained competitive advantage. The results of this study call for a need to adopt different knowledge sourcing approaches for firms of different sizes. Particularly, the results of this study suggest that adopting open innovation impedes a SMEs' innovation performance and adopting closed innovation helps enhance SMEs' innovation performance. Thus, firms must pay due caution when adopting open innovation.



Several limitations of this study are worth noting, some of which offer opportunities for future research. First, although our self-reported performance measure allows a more comprehensive analysis than would otherwise be possible, the results may be dependent on the type of innovation performance measure used. A study could examine performance of SMEs' innovation performance using a more quantitative approach, which would provide for more factual results. Second, this study uses cross-sectional data. Researchers should use longitudinal data to fully understand the impact of knowledge sourcing approaches for innovation on SMEs' innovation performance. Therefore, another avenue to expand this research is to develop and test similar models with longitudinal data. Finally, the results are limited to Korean firms. The generalizability to other countries may thus be questionable. Clearly, replication of this study in other countries would be worthwhile to ensure the generalizability of our findings.

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